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ROENTGEN RADIATION

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ROENTGEN RADIATION

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When the announcement was recently made by Professor Roentgen, of Wurzburg, Germany, that he had discovered a new kind of radiation, it excited so much popular interest, and seemed to have such a far reaching influence in the development of physical science, that we considered it advisable to verify in Toronto at once, as far as practicable, the results obtained by the original investigator

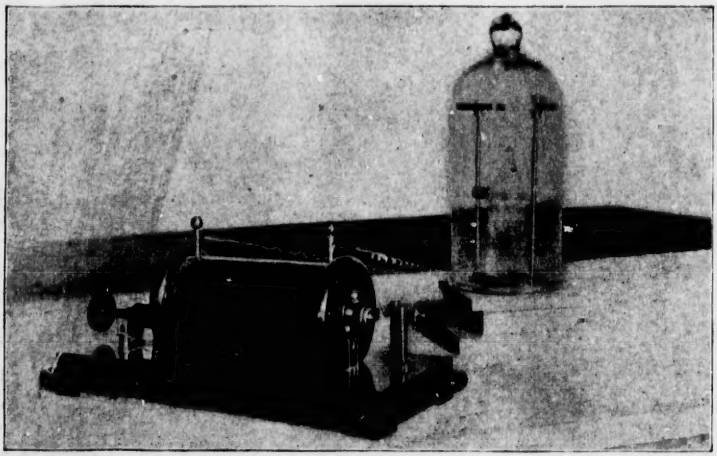

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FIG. 1.

Apparatus showing Induction Coil and Bell-Jar containing Crookes' Tube.

Together with Mr. C. H. C. Wright, B.A.Sc., Lecturer in the School of Practical Science, and Mr. J. Keele, B.A.Sc., of the same institution, the writer repeated these experiments, and found the results exactly as described, and even more wonderful than we had anticipated.

As shown in the accompanying illustration, the apparatus used by us consisted of an induction coil of moderate size and a Crookes' tube of special form.

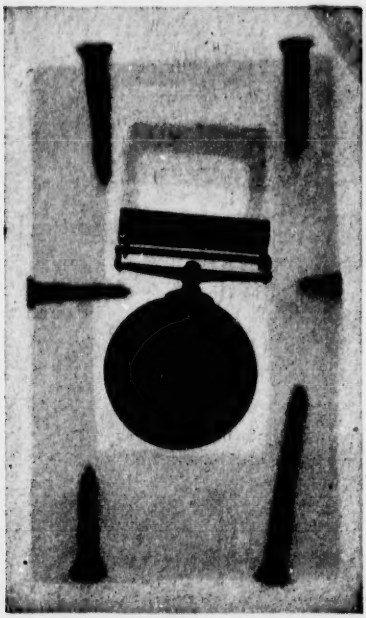

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FIG. II.

Northwest Medal Photographed through a Block of Wood.

Crookes' tubes are made of glass, and were originally designed to exhibit properties of the electric discharge when passed through air at different pressures. The electric current is led into and from them by means of platinum electrodes sealed into the glass and carrying discs or caps of aluminium of different shapes to give variation to the form of the discharge.

When an electric spark is passed through a tube from which the air is being gradually exhausted, it presents a variety of appearances, each being characteristic of the vacuum obtained. At first it consists of a single line of light. It then breaks up into a number of irregular streaks, and this appearance, as the exhaustion goes on, gives place to a bluish colored halo between the electrodes. This halo then breaks up into a

series of parallel discs, and, on pushing the exhaustion still further, these disappear entirely from the negative, but remain in the region of the positive electrode. Here a new appearance is presented. When the air has been exhausted to this degree, the part of the tube directly opposite the negative electrode begins to glow with a beautiful fluorescence, which indicates that some peculiar invisible discharge, causing this effect, is emanating from the negative electrode. It is the cathode rays, so called, which are said to form this discharge, and the tube in this condition constitutes a Crookes' tube.

These cathode rays have been very fully investigated by Lenard, Hertz, Thomson, and others. It is found that, like ordinary light rays, they travel in straight lines, are capable of producing intense heat, and, unless especial care is taken, there is great danger of melting the tube if the discharge is continued without interruption, even for a few minutes.

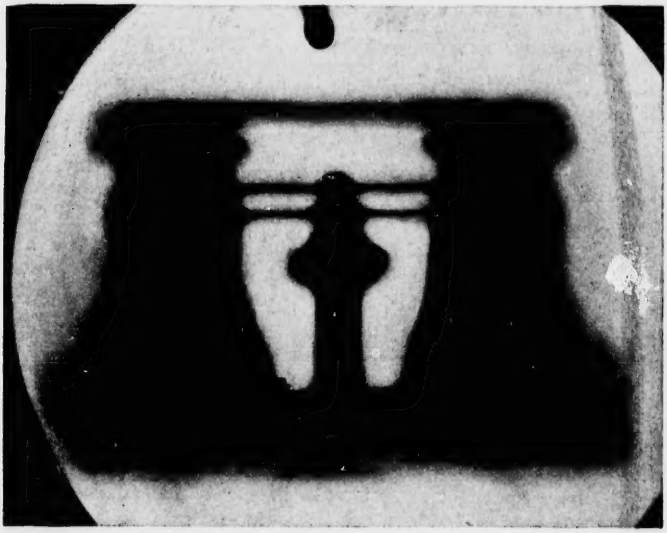

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FIG. III.

Opera Glasses Photographed Through Case.

If a magnet is brought up to the tube when these rays are passing they can be readily deflected from their direct path, and, in fact, a finger presented to the tube is sufficient to deflect them towards the point of contact.

In his early experiments, Professor Roentgen found that on surrounding a Crookes' tube while in action with a close-fitting black paper cover, it was possible to see in a completely darkened room a brilliant fluorescence upon paper covered with barium platino-cyanide held near the tube. This appearance he found to be still visible, though faint, at a distance of two metres. From this experiment he concluded that the Crookes' tube was the origin of the action causing the fluorescence, and that this action, whatever it was, passed through paper which was impervious to ordinary light. Extending his experiments by placing other substances between the Crookes' tube and the fluorescent screen, he found that all bodies allowed this new kind of radiation to pass through them in a greater or less degree. Wood, paper, and water were very transparent, aluminium and ebonite fairly so, while copper, lead, gold, platinum, and even glass were quite opaque unless made in very thin plates. Different thicknesses of various materials were tried, and the results obtained showed that as the thickness increased the hindrance offered to the new rays by all bodies also increased.

The density of bodies seems to be the only property which affects their permeability, and yet their densities alone do not determine completely their transparency, as plates of aluminium, glass, quartz and Iceland spar of equal thickness were interposed between the tube and the screen, and it was quite evident that, although their densities are about the same, the resistances they offered to the passage of the rays were quite different. Although these new rays can be passed through many substances which are opaque to sunlight, no evidence has yet been obtained which would show that they can be refracted. On passing them through prisms, or lenses, of water, carbon bisulphide, ebonite, aluminium or wood, there is no indication, or, if any, but slight, of refraction at these surfaces.

Since many metals and glass of ordinary thickness are found to be impermeable to these rays, it is but natural to expect that these substances would reflect them; but all experiments so far seem to show that the ordinary law of reflection does not hold for these new rays, and that if they can be reflected at all it is only in a very general and irregular manner.

Although this unknown radiation was at first detected and studied by means of a fluorescent screen, it was soon found that ordinary photographic dry plates were sensitive to it, and it is owing to the developments in this direction that such intense interest has been aroused.

The reproductions illustrating this article are from photographs taken in the course of our own investigations, and they will indicate some of

the possibilities of the new discovery. Fig. II. was obtained by placing on the cardboard box containing the sensitized plate a silver medal, over which was placed a block of wood one inch thick. The screws also shown in the picture were driven into the wood, and from the appearance of the

FIG. IV.

Instruments Photographed Through Case.

cut it is quite evident that while the wood offered but little resistance to the passage of the rays the metals were quite opaque. Fig. III. represents a pair of opera glasses taken in their case. The metal parts were of aluminium, and it can be seen that, while the rays passed through the tubes at all points, they did so to a much greater extent where there was only one thickness of the metal. The object lenses are clearly defined, showing that the glass is quite opaque, and the outlines of the

case are indicated but faintly. Fig. IV. shows a set of drawing instruments inclosed in a thick leather case.

The action upon the sensitized film of the dry plate seems to be the same as that due to the light of the sun. The developers used were metol, hydroquinone, pyrogallic acid, and oxalate of potash and iron. Pyro' developer seemed to give best results. The images came up rather more slowly than with ordinary light, and the density as seen before fixing the plate was somewhat misleading, as the chemical action seems to be confined to the surface of the film only. The color of the deposit upon the plate by the various developers is the same as that given by sunlight. Various types of dry plates were tested, but, though we were unable to detect any difference in the action upon them, it may be possible, when more properties of the new radiation are known, to produce a more sensitive film than those now in use.

During our early experiments we found that the time required to obtain good impressions on a plate was so long that the utility of the new discovery seemed to be very limited, even if not doubtful.

We therefore directed our efforts to reducing, if possible, the time of exposure, and this we succeeded in doing to a very marked degree.

On making a careful test of all the tubes in the Physical Laboratory, we found one which gave a much stronger radiation than any of the others. This tube, constructed by Seguy, of Paris, was pear-shaped, and as it had one electrode inserted in the smaller end, and the other in the side, we were able, by making the former the negative terminal, to obtain a large glass surface exposed to the action of the cathode rays. This tube was employed in all our later experiments. Thinking that probably the action would vary with different sensitized films, we conducted a series of tests to determine the relative sensitiveness to the rays of various types of plates, but observed no marked difference, and concluded that any reduction in the time of exposure must be otherwise obtained. As experiments made with prisms and lenses of wood, pitch, and other materials, gave no indication of refraction at their surfaces, the only remaining method for the concentration of the rays seemed to be an application of the principle of reflection. In order to determine whether the rays could be reflected, a surface of clean mercury was prepared, *and it was found that when the rays were directed towards this surface sensitized films protected from direct radiation were fogged by some action coming from the mercury. To test this apparent reflection still further, a sensitized film, protected by a plate-holder, was placed at a distance of about twenty centimetres below the Crookes' tube. A thick plate of glass was then inserted midway between the*

tube and the film, parallel with the latter, with the intention of screening the plate in part from the action of the rays. The tube was then excited for some time, and on developing the film it was found that the rays evidently travelled in straight lines, since the part of the film protected by the glass plate was well defined and entirely unaffected by them. This experiment was repeated, the arrangement of apparatus being identical, with the sole

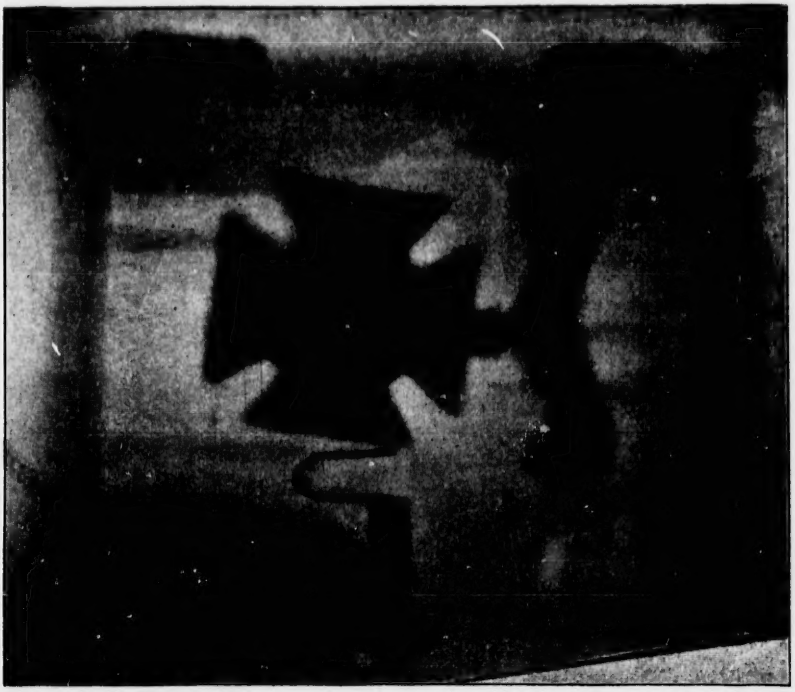

FIG. V.
Medal Photographed in its Case.

exception that a glass bell-jar was placed over the whole. Development o the film in this case showed (1) no action on the film outside the jar; (2) no indication that the interposed plate glass acted as a screen; (3) the action much more intense than in the previous experiment, proving conclusively the reflection of the rays from the surface of the jar.

By the employment of this method we reduced on the 11th February the time of exposure almost to instantaneousness. The picture here given (Fig. V.) was taken with the bell-jar over the apparatus, and was obtained by an exposure of four and a half seconds, the object being a medal placed within a leather-covered wooden jewel case. Very good results were similarly obtained by an exposure of one second through five folds of black paper.

The importance of the new discovery in its application to surgery appears to be somewhat exaggerated. In detecting foreign bodies imbedded in animal tissue, much depends on the character of these bodies, and upon their particular location relative to the bones. In this connection it may be interesting to state that from a photograph of a patient's foot taken by us we located the point of a needle in it so accurately that the surgeon stated he was able by a single incision to remove it. As the needle in this case was situated between two of the bones, the conditions for obtaining a good shadow were rather favorable.

There have been many conjectures regarding the nature of this new radiation, but up to the present its true character remains quite uncertain. As already indicated, it does not pass through glass, and from this it has been concluded that although the cathode rays produce it, it is a form of radiation quite distinct from these rays. This conclusion is further confirmed by the fact that while cathode rays can be deflected from their direct course by a magnet, the latter has no effect on the radiation outside of the tube. It is generally conceded now that when the cathode rays strike upon the glass of the Crookes' tube, vibrations are set up in it which, on being communicated to the space outside, produce what we may now call the Roentgen rays. In fact, it seems to be proven conclusively that this view is the correct one, as Professor J. J. Thomson in his recent experiments found that a sensitized photographic plate placed *inside* a Crookes' tube in the path of the cathode rays was quite unaffected by them. Whether these rays are merely ultra-ultra violet rays, or whether they are due to vortex motions or to the longitudinal vibrations which are supposed to accompany the ordinary light vibrations in the ether, is a problem which has yet to be solved.

I cannot close this article without referring to the assistance given us by President Loudon, of the University of Toronto, and Professor Galbraith, Principal of the School of Practical Science. Much of the success which accompanied our experiments was due to the many valuable suggestions offered by them, and to their kindly placing at our disposal every facility which their laboratories could afford.